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Canada Centre for Mineral and Energy Technology | Centre canad[illegible] de la techno des minérau: et de l'énerg

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PREPARATION AND EVALUATION OF NOVA SCOTIAN INDUSTRIAL MINERALS AS FILLERS AND EXTENDERS

Final Report by
R.K. Collings
Mineral Processing Laboratory

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MICROMEDIA

PREPARATION AND EVALUATION OF NOVA SCOTIAN INDUSTRIAL MINERALS AS FILLERS AND EXTENDERS

by

R.K. Collings*

INTRODUCTION

Following discussions with representatives of the Department of Mines and Energy, Halifax, N.S., and CANMET, Energy, Mines and Resources Canada, Mr. Dennis Stone, president and manager of Magstone Development Inc., Truro, N.S., submitted a proposal on the preparation and use of several Nova Scotian industrial minerals as mineral fillers and extenders, to the Department of Supply and Services, Ottawa, for consideration under the Canada/Nova Scotia Mineral Development Agreement.

Following review of this proposal by, in particular, Mr. D.M. Doyle, federal co-ordinator, Canada/Nova Scotia Mineral Development Agreement, and Mr. R.K. Collings, industrial mineral specialist, both with CANMET, a modified version of Mr. Stone's proposal was accepted in early 1987. The dollar value for this contract was $50,000, and the scheduled completion date was set as December 31, 1987.

Keywords: limestone, dolomite, barite, celestite, kaolin, talc, preparation/evaluation, markets, potential developments

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* Scientific Authority, CANMET, Energy, Mines and Resources Canada; report prepared for D. Stone, deceased, Magstone Development Inc., Truro, N.S., the prime contractor for this work.

PRÉPARATION ET ÉVALUATION DES MINÉRAUX INDUSTRIELS DE LA NOUVELLE-ÉCOSSE POUR SERVIR DE CHARGE MINÉRALE ET DE DILUANT

par

R.K. Collings*

RÉSUMÉ

M. Dennis Stone, président-directeur de Magstone Development Inc., Truro, (N.-É.), suite aux discussions tenues avec les représentants du ministère des Mines et de l'Énergie de la Nouvelle-Écosse à Halifax, et de CANMET, Énergie, Mines et Ressources Canada, a présenté à Approvisionnement et Services Canada, Ottawa, une proposition sur la préparation et l'utilisation de plusieurs minéraux industriels de la Nouvelle-Écosse comme produits de charge minérale et diluants, dans le cadre de l'Entente sur l'exploitation minérale Canada-Nouvelle-Écosse.

Suite à l'étude de la proposition de M. Stone, réalisée tout particulièrement par M. D.M. Doyle, coordonnateur fédéral et M. R.K. Collings, spécialiste des minéraux industriels, tous deux de CANMET, une version modifiée de la proposition susmentionnée a été acceptée au début de 1987. La valeur dollar de ce contrat était de 50 000 $ et la date d'achèvement des travaux avait été fixée au 31 décembre 1987.

Mots-clés : calcaire, dolomite, barite, célestine, kaolin, talc, préparation/évaluation, marchés, développements possibles.

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*Autorité scientifique, CANMET, Énergie, Mines et Ressources Canada; Rapport préparé pour M. D. Stone, décédé, Magstone Development Inc., Truro (N.-É.), fournisseur principal de ce contrat.

The work to be performed under the terms of this contract was detailed in a 'Statement of Work', a copy of which is included in this report as Appendix A. This work related to the examination and evaluation of a number of industrial mineral samples from Nova Scotia including:

- limestone from Glencoe and Marble Mountain
- dolomite from Kelly's Cove and Cape Dauphin
- barite from Scotsville, Pine Brook, and Lake Ainslie
- celestite from the MacRae deposit
- kaolin from Musquodoboit
- talc from the Sterling mine

Delivery of these samples was to be arranged by the Nova Scotia Department of Mines and Energy, Halifax, and by the scientific authority (S.A.).

Various modifications were made to the terms of the contract in view of developed/developing information, and the contract completion date was extended three months, to March 31, 1988, to permit completion of the work. Mr. Stone's death in mid-February, 1988, necessitated the termination of this contract. Received 'deliverables' included monthly interim reports for July, August, September, and October and a rough draft of a final report on Glencoe limestone.

These noted monthly reports and that of the Glencoe limestone, with information derived from discussions and correspondence with individuals and companies directly or indirectly involved in this work, form the basis of this report. Available information unfortunately was incomplete; this report, consequently, is incomplete in some areas.

MINERAL SAMPLES

Sample locations for the 10 mineral samples studied are shown in Fig. 1. To simplify presentation, these samples are considered by mineral type under the following headings:

- Sample identification and description
- Testwork
- Product evaluation or comment

The contract stipulated that a major study would be made on two of the samples; these were to be identified during the course of the study. Glencoe limestone and Scotsville barite were selected for larger-scale testing. The work on the Glencoe sample was found to be relatively complete. Unfortunately, little work appears to have been done on a larger sample of Scotsville barite.

LIMESTONE

Glencoe

Sample identification and description:

A 45 kg sample of Glencoe limestone was provided by the Nova Scotia Department of Mines and Energy. The sample consisted of pieces of rock up to 40 cm in size. The limestone was very finely crystallized and the individual pieces were heavily iron-stained. A second, sample (45 kg) also was iron-stained and weathered on the surface.

Test work:

A representative sample was crushed to 2.5 mm by jaw crusher and finely ground, to about 2 µm, in a Magstone-developed Paddle mill, with and without a bleaching agent (hydrogen peroxide). Sized samples of the unground rock

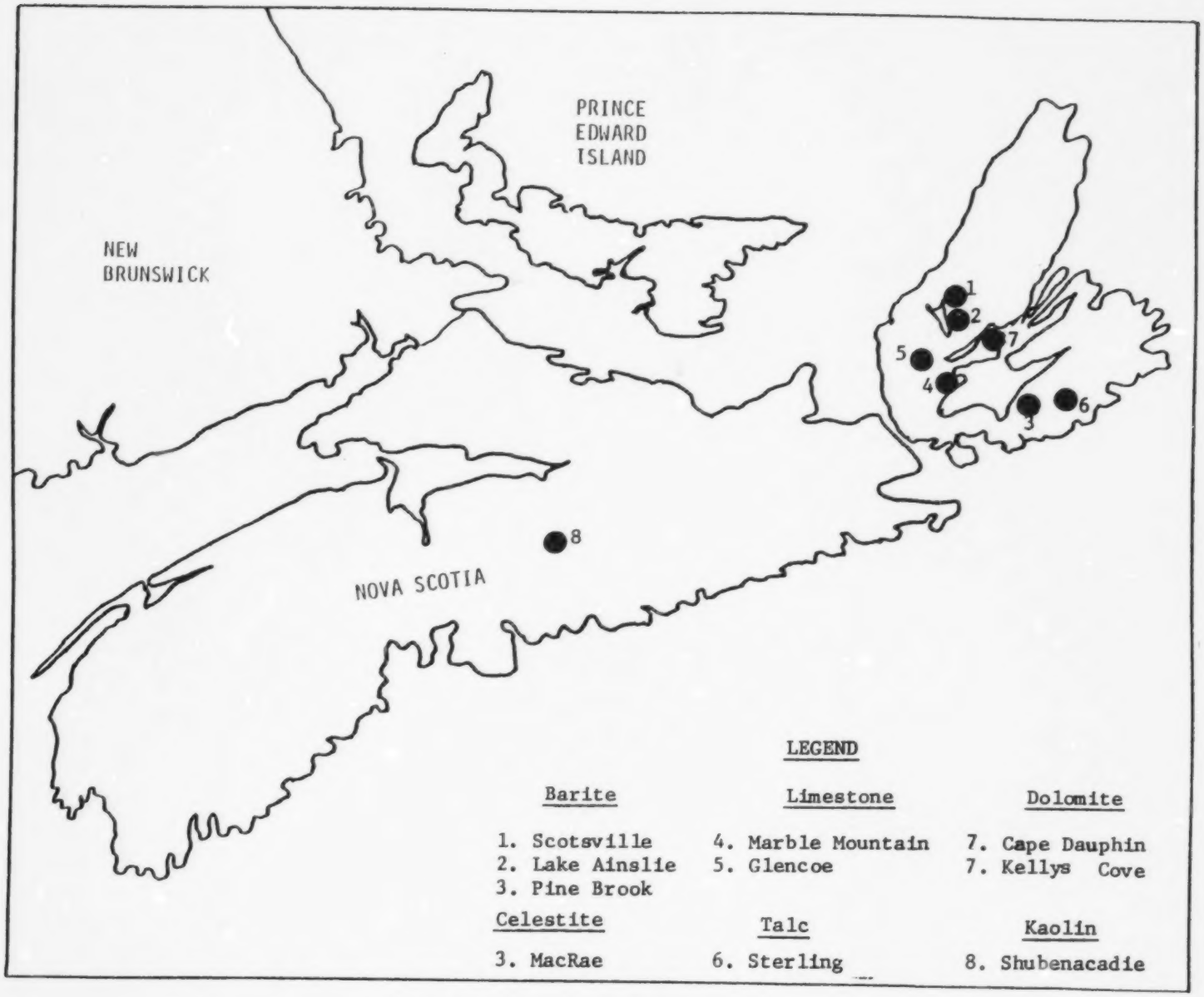

Fig. 1 - Locations of Magstone samples.

were treated by wet tabling and high-intensity magnetic separation in an attempt to reduce iron impurity. Representative specimens from the second sample were surface-washed with dilute hydrochloric acid or, alternatively, lightly sand blasted to remove surface staining and weathering.

Product evaluation:

Scrubbing in the Paddle mill and water washing removed much of the iron staining from the individual particles. Magnetic separation removed a small quantity of unidentified iron minerals; however, tabling results were disappointing. Both the light acid wash and sandblasting successfully removed most of the surface iron staining/weathering and substantially improved the 'whiteness' of the second sample of limestone. Mr. Stone observed that Paddle-mill grinding alone also produced a marked improvement in whiteness. On the basis of the above tests it would appear that this stone has good potential for the production of high quality white filler products.

Small, 5 kg samples of the ground product, both ground in water and in varsol, were submitted to Tibbets Paint Company, Trenton, for evaluation as an additive and pigment in paint. This company now uses high-grade calcite from Ontario in its paint formulation and appeared very interested in the possibility of obtaining a comparable product locally.

A report by Tibbets Paint Company is included as Appendix B. This report showed two of the three samples of Glencoe limestone to be satisfactory for use as a filler in highway paint.

A brightness (whiteness) value of 93 was obtained by Magstone with the Glencoe product compared to 94.5 for top quality Ontario calcite, and a range from 85 to 96 for various other ground Ontario calcite products.

The oil absorption index for ground Glencoe limestone was 29.5 g/ 100 g (29.5 g of oil per 100 g of calcite) compared to a general range from 10 to 30 g/100 g for commercial calcites used by the paint industry.

Loss on ignition (CO_2) and iron determinations were conducted at the Technical University of Nova Scotia (TUNS), Halifax, N.S. Reported results were as follows:

	Fe_2O_3	LOI*	$CaCO_3$**
Feed	0.043	43.17	98.11
Product	0.047	42.50	96.59

* after removal of surface staining

** calculated

The $CaCO_3$ content of the product, unexpectedly, is less than that of the feed. This is surprising but possibly could have resulted from the light acid wash.

Figures 2 to 5, provided by Magstone Development Inc., depict various experimental steps in the processing, beneficiation, and evaluation of Glencoe limestone.

Reserves of high-quality limestone at Glencoe have been estimated at 3 million tonnes.

Note:

The concept of Paddle mill grinding in varsol, developed by Mr. Stone, was based on the fact that paint formulators add varsol during preparation of paint mixes. Introduction of varsol at the pigment-grinding stage, and shipment of a varsol/filler "slurry", could result in some cost saving for both the pigment producer and the paint company.

Marble Mountain

Sample identification and description:

A 10 kg sample of Marble Mountain limestone was provided by the Nova Scotia Department of Mines and Energy. The sample consisted of pieces of rock up to 40 cm in size. The sample appeared to be high grade, the chief

contaminant being surface iron-oxide staining. A later examination of the deposit by R.K. Collings, S.A., and Peter Luke, N.S. Dept. of Mines and Energy, Halifax, indicated this sample to be, in fact, high grade and therefore not representative of the average grade of stone available at Marble Mountain.

Testwork:

The sample was reduced to 2 mm by jaw crusher and a representative portion finely ground, to 2 µm, in a Paddle mill with and without bleaching agent.

Product evaluation:

The ground product was white in colour and undoubtedly suitable for top-quality uses such as a filler in plastics and as a filler/extender in paint.

Experimental work by Magstone Development Inc. is depicted in Fig. 6 and 7.

DOLOMITE

Kellys Cove and Cape Dauphin

Two 10 kg samples, one from Cape Dauphin, the other from Kellys Cove, Cape Breton Island, were obtained from Mr. Roy Mosher who operates a quarry at Kellys Cove for the production of stone dust, agriculture stone and aggregate. No description of these samples appeared in Mr. Stone's notes; however, he does state that these samples were processed (crushed and finely ground) to produce high brightness products.

Experimental work by Magstone on Cape Dauphin dolomite is depicted in Fig. 8.

BARITE

Scotsville

A 100 kg sample of stockpiled ore was obtained from the Scotsville mine. The sample consisted of lumps up to 15 cm size of mottled grey to white barite.

Testwork:

The sample was reduced by jaw crusher and representative portions treated by wet jigging and tabling. Tabling proved to be more beneficial than jigging. Samples of the table concentrate were treated in the Jones high-intensity wet magnetic separator and, finally, acid leached.

Product evaluation:

The leached product was of high purity and white in colour. This product undoubtedly would be satisfactory for use as a mineral filler in paint and plastics and in the manufacture of pharmaceutical formulations for X-ray applications. The table product, ground to 45 µm, could be utilized in oil-well drilling muds. A number of samples reportedly were prepared for analysis but there appears to be no record of results.

Experimental work by Magstone on Scotsville barite is depicted in Fig. 9 to 12.

Comment:

Previous work by CANMET[1] had confirmed the technical feasibility of producing mud-grade barite of 4.2 S.G. from 15 mm Scotsville ore by jigging; however, further reduction to, say, 0.5 mm was required for complete liberation of the barite prior to table tests.

Mr. Stone had interest in the production of a barite block or board, the latter resembling standard gypsum board, for use as a gamma ray shielding material in X-ray rooms at hospitals. This aspect of his work on Scotsville barite was being carried out under a separate, MISP contract with the Nova Scotia government.

Pine Brook

Sample identification/description:

Two 25 kg samples of Pine Brook barite, one of low-grade, the other of high-grade ore, were obtained from TUNS (Technical University of Nova Scotia), Halifax. These were representative of material delivered to TUNS by the Nova Scotia Department of Mines and Energy for earlier work under the Canada/Nova Scotia Mineral Development Agreement (DSS File No. 38ST. 23440-6-9083)(2). The low-grade ore sample was minus 20 mm in size, and averaged 23% $BaSO_4$; the high-grade was minus 5 mm in size and analysed 71.5% $BaSO_4$.

Test work:

The two samples were separately crushed by jaw crusher, screened, and representative samples treated by wet tabling at TUNS' Halifax laboratory. The results were disappointing in that tabling produced little improvement in the overall grade of these samples. A second series of samples were treated in the Jones high-intensity wet magnetic separator but little upgrading of the feed material was achieved.

Experimental work by Magstone on Pine Brook barite is depicted in Fig. 13.

Comment:

Pine Brook barite, because of finely disseminated limestone/dolomite impurity, is difficult to beneficiate by gravity methods of separation, even

to achieve a mud-grade product (90% $BaSO_4$). Slightly better results may have been achieved had Magstone used ore samples beneficiated by TUNS, (jigging followed by regrinding of the jig concentrate prior to tabling). Recovery of mud-grade barite by TUNS was in the order of 70%. The best approach to beneficiating this ore would include preliminary gravity concentration by jig and table followed by fine grinding and froth flotation. However, it is unlikely that the resulting product would be applicable as mineral filler in, for example, paint because of its grey colour and relatively high cost of beneficiation.

Lake Ainslie

Comment:

The Lake Ainslie ore is very difficult to treat because it contains very finely divided fluorite impurity. By mutual agreement (S.A. and contractor), Lake Ainslie ore was dropped in favour of more detailed work on the other two barite ores, Scotsville and Pine Brook, with particular emphasis on the former.

CELESTITE

MacRae

Sample identification/description:

As arranged by the S.A., two samples of MacRae celestite, one of ore, the other of concentrate, were obtained from Lakefield Research, Lakefield, Ontario. Lakefield had recently completed beneficiation studies of MacRae celestite under terms of an earlier Canada/Nova Scotia Mineral Development Agreement (DSS File No. 03SQ.23440-6-9031)[3]. The ore (feed) sample weighed 100 kg and was minus 7 mm in size. The sample of concentrate weighed 10 kg, was 80% minus 75 µm in size, and representative of flotation concentrates from the Lakefield study. It reportedly contained minor amounts of sulphide impurities.

The chemical analyses of the samples, as reported by Lakefield Research, were as follows:

	Ore (Feed)	Triflow Concentrate
$SrSO_4$	70%	94.6%
$BaSO_4$	1.1	1.39
$CaCO_3$	13.5	1.87
$MgCO_3$	4.8	0.67
Fe_2O_3	0.5	0.12
SiO_2	4.5	0.35
Al_2O_3	0.8	0.10
Pb	2.0	0.16

Testwork:

A representative portion of the Lakefield ore sample was finely ground to approximately 2 µm in the Paddle mill, with and without a bleaching agent (hydrogen peroxide). The ground product was washed, treated in a Jones high-intensity magnetic separator, and the non-magnetic product leached with hydrochloric acid to improve whiteness.

Product evaluation:

The product was reported to be of 'good whiteness' and to have potential for use as filler mineral. A sample of the prepared material was forwarded to Chromasco, Haley, Ont. for comment. Chromasco provided little in the way of comment other than that the sample was white in colour and quite pure. Chromasco has a lease on the property and has interest in developing the ore body to produce chemical-grade strontium carbonate for use in the manufacture of strontium metal at Haley, and for sale to United States and foreign markets.

Experimental work by Magstone on MacRae celestite is depicted in Fig. 14.

KAOLIN

Musquodoboit

Sample identification/description:

A 25 kg sample of kaolin was obtained from stockpiled material near Shubenacadie by the S.A. and Mr. Peter Luke of the Nova Scotia Department of Mines and Energy, Halifax, and delivered to Magstone's Debert laboratory. The sample was gray-white in colour, finely divided, and relatively pure. This kaolin is recovered during open-pit clay mining operations and used by L.E. Shaw Ltd. for brick manufacture at Shubenacadie.

Testwork:

The laboratory work essentially consisted of mixing and settling tests to separate impurities and recover high-purity kaolin. The suspended kaolin was separated by siphon and acid leached to remove iron staining; although the resulting product was white in colour, it was very difficult to filter. Mr. Stone indicated that the only practical solution to this problem was the use of an expensive pressure filter.

Experimental work by Magstone on Musquodoboit kaolin is depicted in Fig. 15 to 18.

Comment:

Recovery of kaolin from this particular source does not appear particularly attractive for the following reasons:

- low recovery of kaolin from the clay pit
- high cost of the acid leach/filter process
- competition from existing supply sources for kaolin
- replacement of kaolin in paper manufacture by calcium carbonate as a result of the gradual change-over from acid to alkali pulping technology

In view of the above, and following this initial testwork, it was mutually agreed by the S.A. and Mr. Stone that he should dispense with further work on Musquodoboit kaolin. However, Mr. Stone planned to further discuss the prospects for this kaolin with officials of L.E. Shaw, Ltd., particularly with regard to its possible utilization in place of talc for the production of a light-weight absorptive material for the control of oil spills. This process was under development by Magstone and quite separate from this present contract.

TALC

Sterling

Comment:

No talc sample was obtained for study; the talc identified in the original proposal was, in fact, waste talc from the flooded Sterling mine. This had been dumped on the surface 50 or more years ago. It was non-representative of any deposit and therefore deemed to be of little interest for the current study. In correspondence, Mr. Stone noted interest by certain gold producers in talc showings in drill core samples. He had planned to further investigate this to determine the feasibility of the recovery of such talc as a by-product of gold operations. His interest in this regard was in the use of this talc not only as mineral filler additive, but also for the production of an oil-absorbing talcose product by a patented Magstone process.

MARKET DEVELOPMENT

Investigation of possible markets for mineral fillers by Magstone pointed to calcium carbonate as having the most potential for development as a mineral filler in Atlantic Canada, specifically for use in paint, paper, plastics and pharmaceuticals.

Calcium carbonate is already extensively used in paint and plastics and appears to have significant growth potential in paper in view of a trend

toward the alkali process and away from the acid pulp digestion system, which could result in a markedly increased use of calcium carbonate as a filler/coater by the paper industry.

Mr. Stone contacted Mr. Roy Mosher, Mosher Limestone Co. Ltd., Upper Musquodoboit, re the possibility of operating a joint coarse/fine grinding facility at Kellys Cove near Baddeck to produce construction and agriculture limestone/dolomite as well as limestone for use as filler in paint, plastics, paper and pharmaceuticals. Mosher Limestone is already established with a custom crushing/grinding plant at Kellys Cove. This plant has the capability of Raymond roller-mill grinding to 45 µm. The associate plant envisioned by Magstone would further grind to 2 µm by Paddle mill, the two associated mills being capable of producing 20,000 t/a of ground product utilizing dolomite from Kellys Cove and/or Cape Dauphin with limestone from Glencoe and Marble Mountain as alternative sources of raw feed.

CALCIUM CARBONATE PLANT

A rough draft of a report on the feasibility of establishing a grinding facility in Cape Breton, based on Glencoe limestone, was submitted by Magstone Development during the last quarter of 1987. This is included as Appendix C. A summary of that report, in point form, follows:

1. The north American market for chemical grade limestone is estimated at 3 million tons/year; Stone assumed that about 1/3 of this market, essentially eastern Canada and north-eastern United States, would be 'accessible' to a limestone producer sited in Cape Breton.

2. The proposed Cape Breton plant would be capable of producing 20,000 tons of ground, high-purity limestone annually which is equivalent to only 2% of the noted accessible market; a five-fold increase in production, to 100,000 tons/year, equal to 10% of the accessible market, is envisioned within 5 years of start-up.

3. The fine grinding/purification plant would be sited adjacent to Mosher Limestone's newly established dolomite grinding facility at Kellys Cove, near Baddeck. Initial grinding of Glencoe limestone, to 45 µm, would be performed at the Mosher plant with final grinding, to 2 µm, being done at the proposed new facility; fine grinding and purification would involve Paddle mill grinding and use of a bleaching agent, hydrogen pyroxide, to improve whiteness. Magstone makes reference to ozone creation during fine grinding with an accompanying improvement in colour (whiteness) of the ground product. This claim has not been substantiated. The company reportedly had applied for a patent on the grinding/bleaching process.

4. Capital costs of calcium carbonate plant

Building, 16,000 sq. ft. @ $50,00	= $ 800,000
Equipment	= 1,670,000
Electrical/mechanical services, 60% of equipment	= 1,002,000
Plant commissioning	221,000
Total estimated plant cost	$3,693,000

5. Operating costs

Year 1 - 5,000 tons	$176.60/ton
" 2 - 10,000 tons	$147.10/ton
" 3 - 20,000 tons	$130.85/ton

6. Market pre-production costs

Market pre-production costs include production of an adequate supply of product for evaluation by potential customers and sales promotion, the market thrust being largely aimed at plastics, paper, paint and pharmaceuticals, and split 50:50 between Canada and the United States.

Material preparation	$50,240
Marketing (sales promotion)	29,000
Total	$79,240

7. Capital requirement

The capital requirement for this integrated, fine-grinding plant is estimated at $4 million; the plant would employ 18 people and have an estimated annual sales of $3.4 million based on the production of 20,000 tons/year of high-purity, minus 2 μm limestone. The estimated operating cost is $307,000 (capital requirement less capital cost).

8. Estimate average selling price of ground products

Product	Price Can $/ton
2-4 μm, wet	176
2-4 μm, dry	187
2-3 μm, coated	223
1 μm, slurry, 70% solids	221
1 μm, dry	304

Note:

Magstone used an estimated selling price of only $170/ton in calculations relating to product sales.

9. Calculations relating to the cost of feedstock, (minus 45 μm Glencoe limestone from Mosher Limestone's plant), and end product sales, (minus 2 μm product from Paddle mill, bleached), are summarized as follows:

	Year 1	Year 2	Year 3
Feedstock (t/a)	5,000	10,000	20,000
Cost ($/t)	45.00	42.50	40.00
Product cost ($ total)	225K	425.5K	800K
Estimated sales (t/a)	5,000	10,000	20,000
Selling price ($/t)	171	171	171
Total sales ($ total)	885K	1,710K	3,420K

CONCLUSIONS

The unfortunate death of Mr. Dennis Stone, the prime mover of this contract, before its completion has left some unanswered questions. It appears:

1. that although grinding/beneficiation studies were carried out on all submitted mineral samples, available supporting data, e.g., physical and chemical analyses of samples and products, are minimal.

2. that contact with prospective consumers and submission of ground filler products for evaluation was minimal and apparently limited to the limestone samples sent to Tibbets paint and the one sample of celestite sent to Chromasco.

3. that the end result of the Magstone study was the identification of Glencoe limestone and Scotsville barite as being the best 'bets' for commercial development, the former to provide calcium carbonate filler for use in paints, plastics, paper products, and pharmaceuticals, the latter ground barium sulphate for paint, for drilling mud formulations, for pharmaceuticals, and in gamma-ray shielding for use in hospitals.

This report has been prepared from information supplied by Magstone in monthly reports, from Magstone files in Montreal, and in Truro and Debert, Nova Scotia, from numerous discussions with interested parties, and from the writer's personal knowledge of the project. Although information is incomplete, the report nonetheless points to the distinct possibility of developing the Glencoe limestone resource, in particular, for the production of high-grade calcium carbonate filler in association with Mosher Limestone's established mill facility at Kellys Cove. Magstone's studies, in this regard, were successful in that they identified this interesting potential development.

RECOMMENDATION

It is recommended that the possibility of developing the Glencoe limestone resource for the production of high purity calcium carbonate filler for paints, plastics, paper products and pharmaceuticals, be pursued at both the provincial and federal levels of government. It is further recommended that such development be integrated with Mosher Limestone's existing fine grinding facility at Kellys Cove as envisioned and recommended by the late Mr. Stone, and as supported by Mr. Roy Mosher of Mosher Limestone. Further details re Mosher Limestone and this proposal are included as Appendix D.

Attention also should be directed towards the possible development of Scotsville barite as a filler in paints, in pharmaceuticals, for gamma-ray shielding in hospitals, and for use in oil-well drilling muds.

REFERENCES

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3. CHROMASCO, a Division of TIMMINCO LTD., "Studies of MacRae celestite, Lake Enon, Cape Breton," MDA Contract, D.S.S. File No. 03SQ. 23440-6-9031, 1987, (S.A. - R.K. Collings, CANMET).

Fig. 2. Glencoe limestone, lump, crushed and ground; note, in particular, the surface discolouration of the lump material and the colour improvement with grinding, particularly with fine grinding.

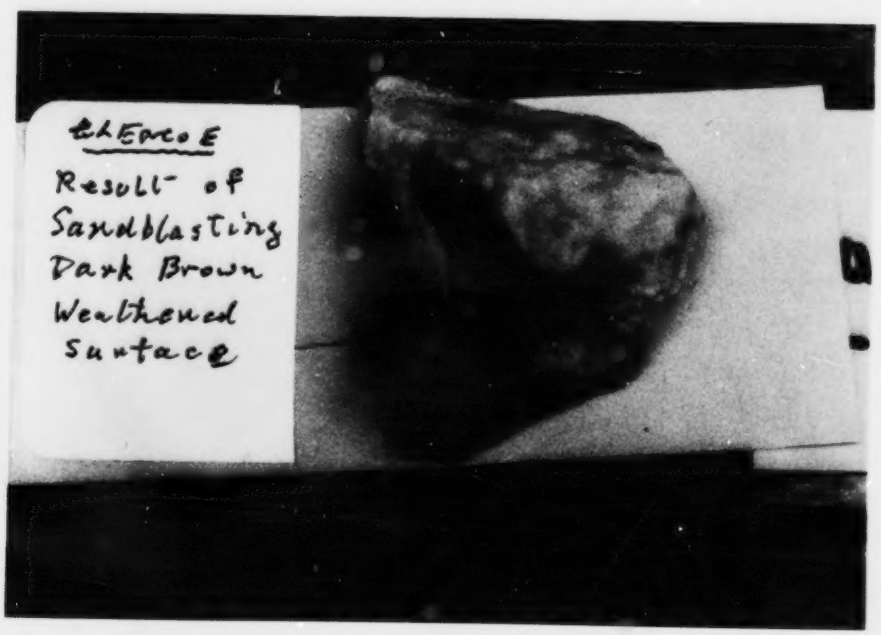

Fig. 3. Glencoe limestone, lump, demonstrating removal of surface impurity by sand blasting.

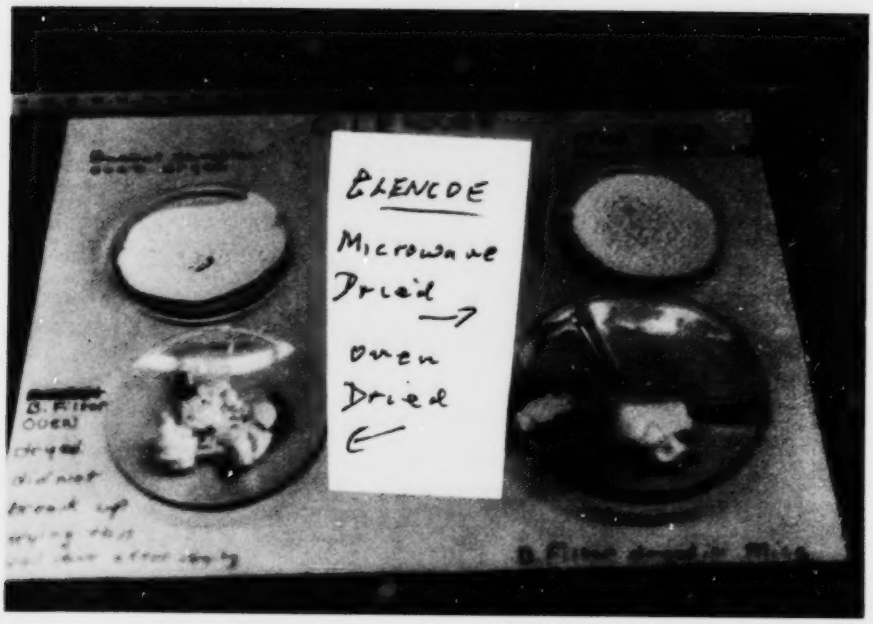

Fig. 4. Glencoe limestone; experimental drying using standard oven and microwave unit.

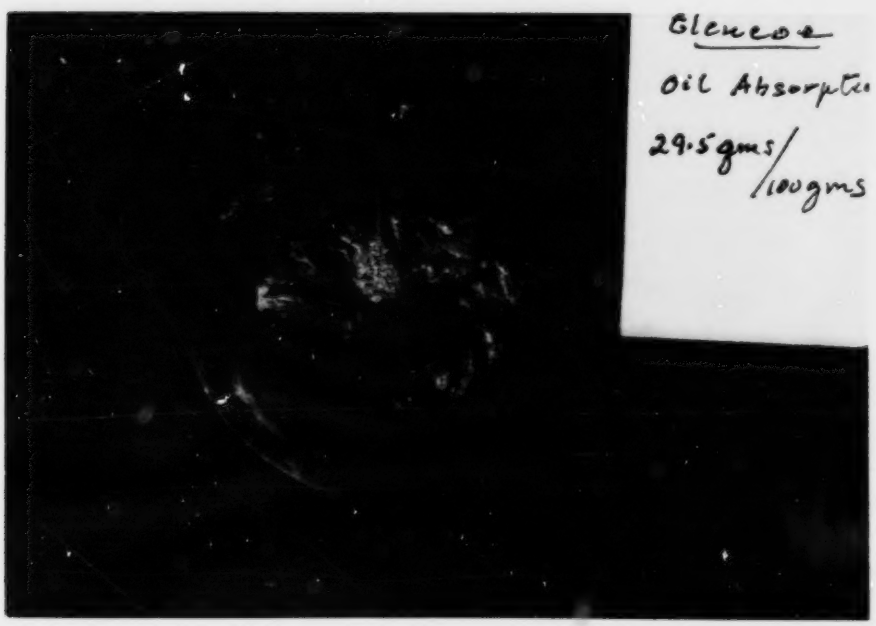

Fig. 5. Glencoe limestone; oil absorption experiment, a standard test for paint pigments.

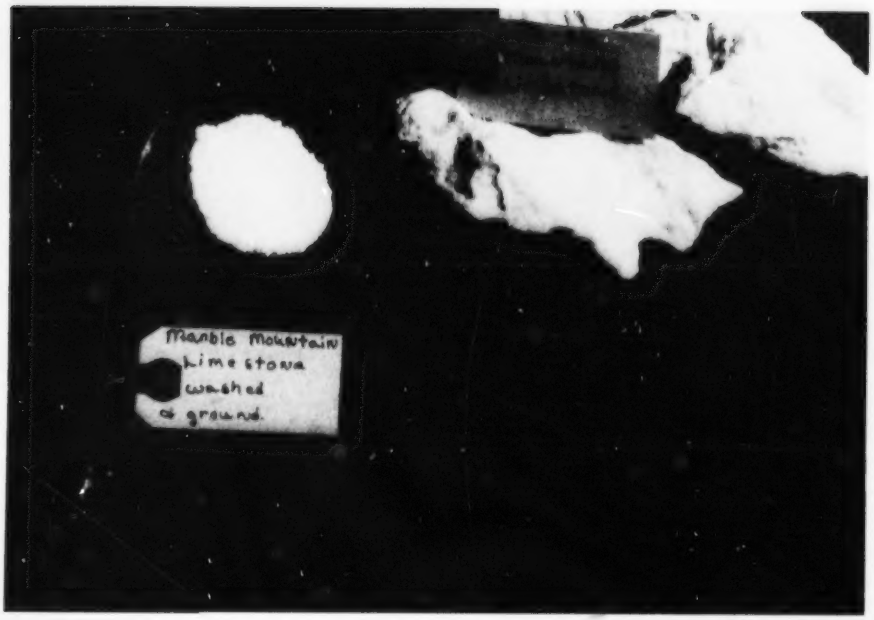

Fig. 6. Marble Mountain limestone; lump, washed and ground material.

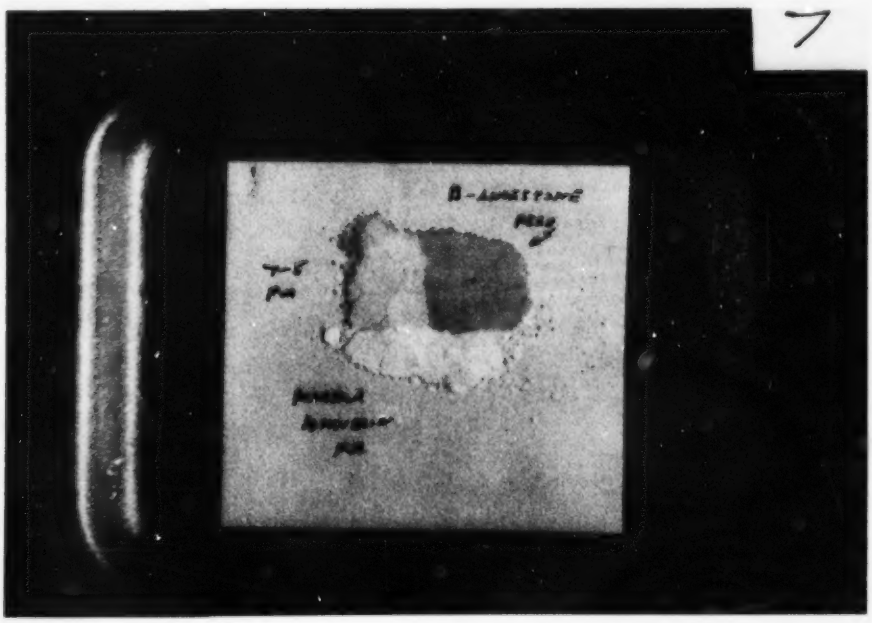

Fig. 7. Marble Mountain limestone; colour improvement by Paddle mill grinding with bleaching agent.

Fig. 8. Cape Dauphin dolomite; lump and ground material (325 mesh/45 μm).

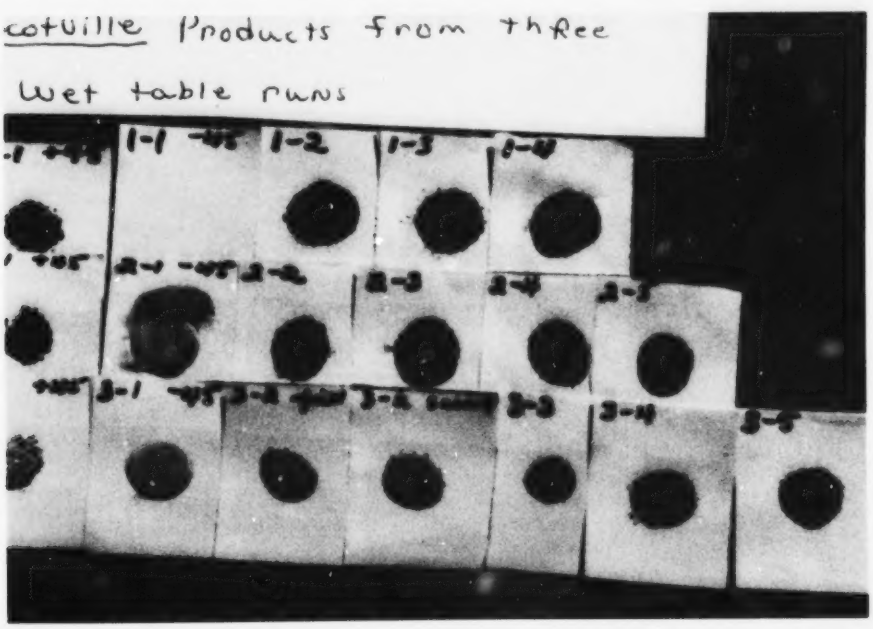

Fig. 9. Scotsville barite: wet table products; a significant concentration was achieved in Test 2, products 2-1, -45; 2-2, and in Test 3, products 3-1, -45; 3-2 first; 3-2, second. The coarse, +45 mesh ore, (1-1, +45; 2-1, +45; 3-1, +45), was removed prior to wet table tests.

Fig. 10. Scotsville barite: wet table products showing good concentration of barite in 3-1, 3-2 first, and 3-2 second, fractions.

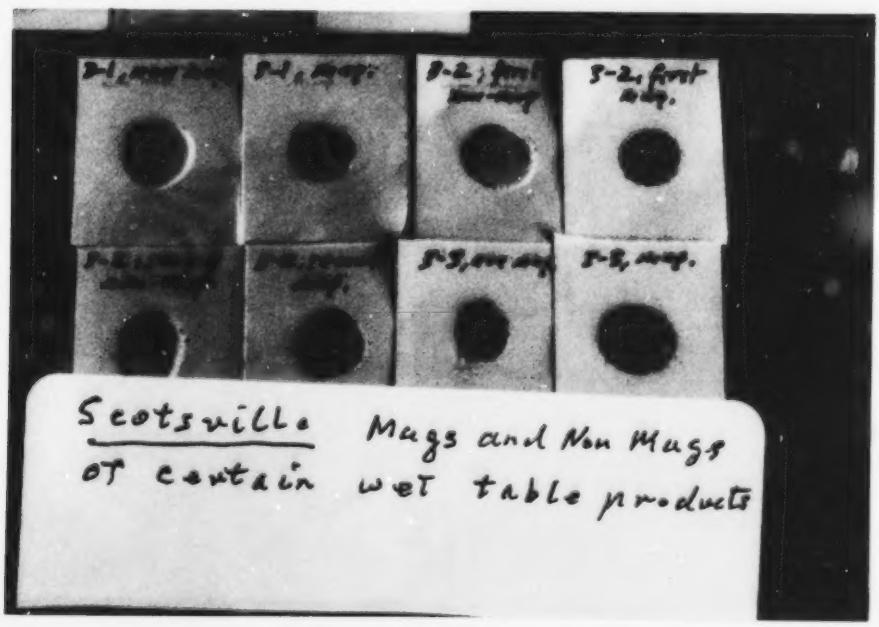

Fig. 11. Scotsville barite: products from Jones high intensity wet magnetic separator showing good concentration of white barite, particularly in products 3-1, non-mag.; 3-2 first, non-mag., and 3-2 second, non-mag.

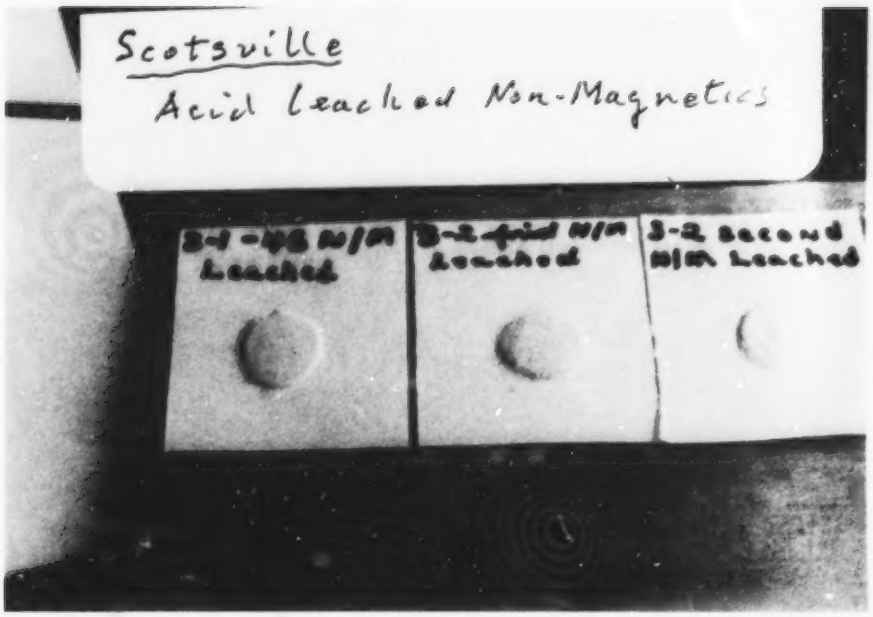

Fig. 12. Scotsville barite: acid-leached, non-mag. products.

Fig. 13. Pine Brook barite: low grade and high grade ore prepared for feed to the wet table.

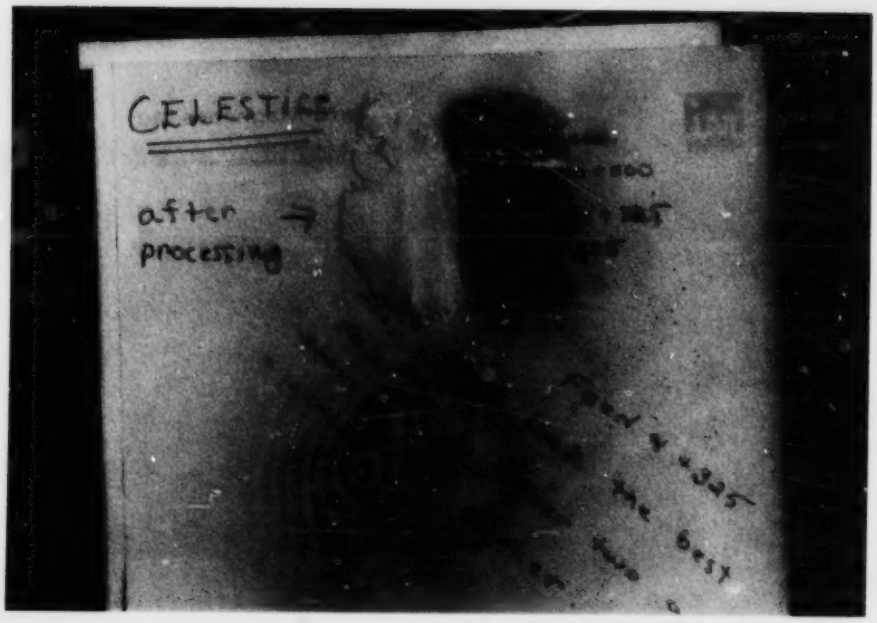

Fig. 14. MacRae celestite: showing three sizes of Paddle mill feed (right side, -100, -200 +325, -325 mesh), and Paddle mill product (left side).

Fig. 15. Musquodoboit kaolin: head sample.

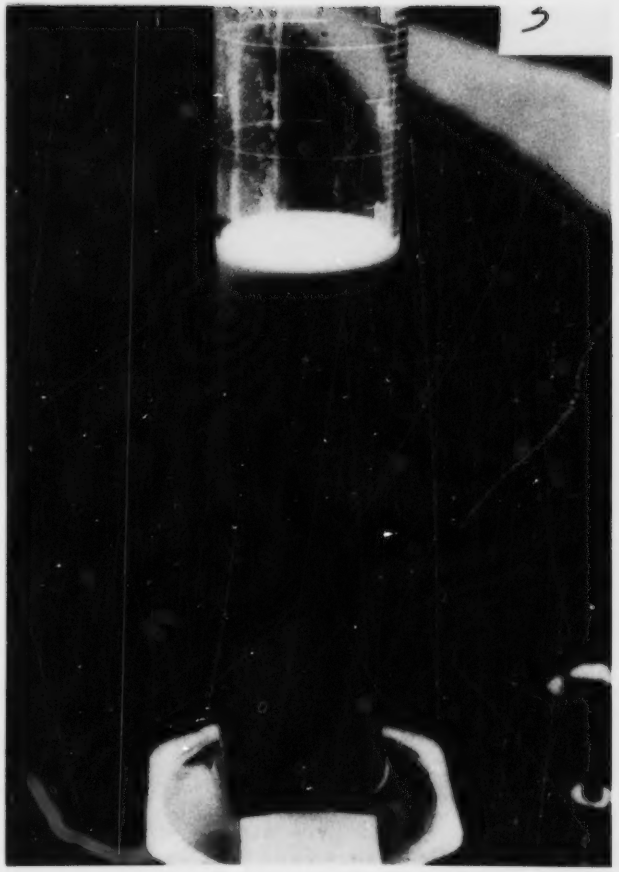

Fig. 16. Musquodoboit kaolin: water slurry for sedimentation tests.

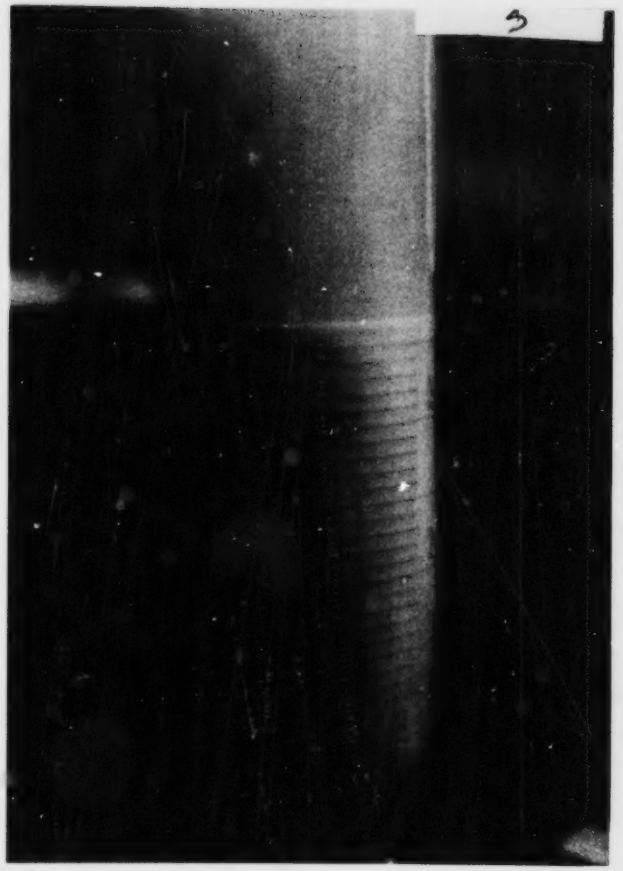

Fig. 17. Musquodoboit kaolin: sedimentation test showing good separation of white kaolin from red clay.

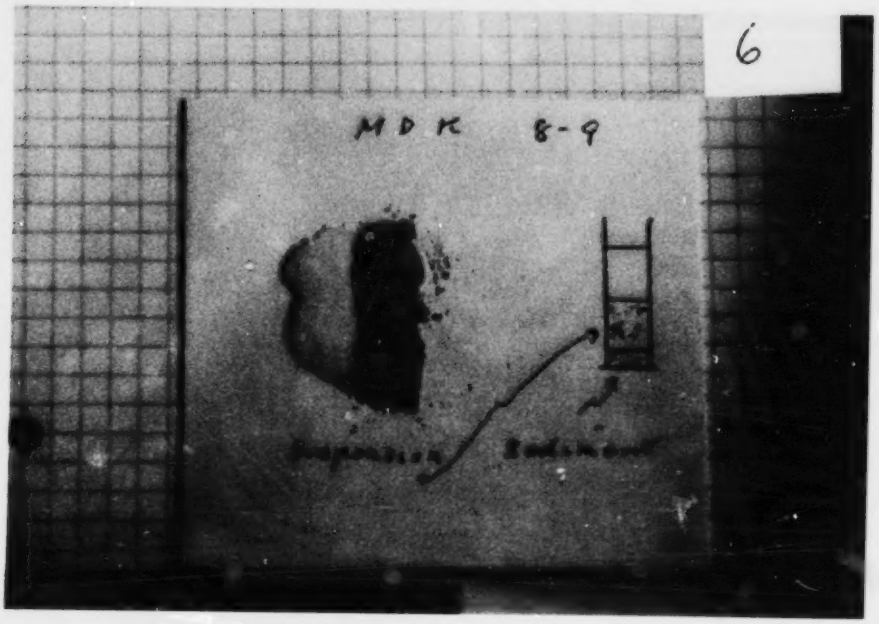

Fig. 18. Musquodoboit kaolin: typical products from sedimentation tests; white leached kaolin on left, impure kaolin/clay sediment on right.

APPENDIX A

STATEMENT OF WORK

(DSS 07SQ.23440-6-9163)

STATEMENT OF WORK

TITLE: Preparation and Evaluation of Certain Nova Scotia Industrial Minerals for Use as Fillers and Extenders.

This project will investigate the potential for producing high price, ultra fine and pure industrial minerals from a number of sources in Nova Scotia.

Nova Scotia Dept. of Mines and Energy will supply 20-50 kg samples from the following deposits.

Barite from Scotsville, Lake Ainslie and Pine Brook,
Talc from Sterling Mine
Limestone from Marble Mtn and Glencoe
Dolomite from Cape Dauphin and Kellys Cove
Kaolin from Musquodoboit
Celestite from Lake Enon

The contractor will be expected to complete the following;

- crush and analyse each of the 10 samples for key elements;

- process each of the 10 samples to remove impurities using several separation devices, including gravity techniques, i.e., jigs and tables, and high intensity magnetic separator, flotation and leaching;

- process the concentrates through a laboratory Paddle mill to produce minus 1 µm micron size finished products as measured by Sedigraph PSA analyser;

- analyse the concentrates for appropriate elements and carry out physical analyses including whiteness, density, particle size, inertness and oil adsorption;

- obtain from NSDME 1 to 2 tonne samples of at least two ore samples that indicated potential applications in targeted ultra pure fine ground markets;

- process these 1 to 2 tonne samples through the flowline indicated from the bench scale tests to yield marketable, pure fine-ground products;

- perform chemical and physical analyses on final products, i.e., sedigraph PSA, trace element, chemical analysis, whiteness, etc.

- make contact with prospective purchasers of these products and submit samples for their evaluation;

- compile results of investigations, make comparisons between potential fine ground high purity products from Nova Scotia and those presently marketed from other sources;

- determine mining, milling and marketing requirements to achieve a 10,000 to 50,000 tpa output, listing major items of equipment, flowlines, energy requirements and general infrastructure;

- determine order of magnitude capital and operating costs, and return on investment to produce 10,000 and 50,000 tpa of product for an identifiable market.

APPENDIX B

LABORATORY REPORT

ON

GLENCOE LIMESTONE

(TIBBETTS PAINT CO. LTD.)

$CaCO_3$ from Magstone Development

by

Fred Hughes

INTRODUCTION

Three samples of calcium carbonate from Magstone Development were obtained.

The sizes of the three samples were:

15 µm (Magstone 1), 10 µm (Magstone 2), 5 µm (Magstone 3)

PROCEDURE

These three samples were each used to produce sample batches of #232 (regular traffic paint). Care was taken that each was prepared the same (ie: order of addition and mixing time).

When these paints were finished their grinds were checked as well as draw downs made. (This was to compare results with one of our batches of #232).

RESULTS

The following table summarizes the results.

	Tibbets #232	Magstone 2*	Magstone 4	Magstone 6
Grind	3½	poor approx. 1½	5	3
Color Comparison	standard	**	.95	.99

* Magstone 2 denotes Magstone sample 15 µm, etc.

** No color comparison was performed as this paint was found to be too rough and totally unacceptable.

CONCLUSION

From the data it can be concluded that the Magstone calcium carbonate could be used in traffic paint but only the 10 µm or 5 µm sizes.

Please note that the 10 µm sample performed better than the 5 µm sample. One explanation for this is a possible mix up of samples, where 10 was marked 5 and 5 marked 10 by mistake. In either case both were found acceptable with only a slight color difference.

APPENDIX C

DRAFT REPORT ON GLENCOE LIMESTONE

(Magstone Development)

CONTENTS

Introduction
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Financial Comments
Feedstock Costs
Capital Costs
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Marketing Pre-Production Costs
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Operation of Company
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Possible Canadian Users 2

Calcium Carbonate
Data Collection

3
Steep Rock Resources

INTRODUCTION

Industrial minerals, rather than metallics, now show overwhelming growth potential.

This growth further is enhanced by the increasing ability to process industrial minerals "on site" ie: at quarry rather than being produced by chemical precipitation.

Much of the advantage of "on site" processing is due to fine grinding techniques. These are further enhanced by incorporated processing.

Historically, Magstone's principal created plants to achieve the above are directly related to:

a) Iron Oxide
b) Ferrites
c) Pharmaceutical Barium Sulphate
d) Iron Powder
e) Strontium Carbonate

The chemical compound, Calcium Carbonate, has established a very stable growing market of over 3,000,000 tons in North America (1987). This is not to be confused with limestone for other uses such as roadstone, concrete, agriculture, etc.

The Glencoe deposit in Cape Breton has:

a) a proven large deposit
b) a proven process

The projected plant capacity of 20,000 tons/year, represents only 2.2% of the accessible market. The expansion of this plant to 100,000 tons/year by end of year 5 is not unrealistic.

Cape Breton enjoys the enviable position of having:

a) suitable deposits
b) year round shipping
c) available labour force
d) aggressive attitude
e) in this instance, having Mosher Limestone as the operator.

As in all new plants, markets have to be penetrated. However, this initial plant has the advantages of.....

SUMMARY

1. Innovative new plant for Cape Breton processing a Cape Breton mineral to produce Calcium Carbonate

2. Capital Requirement - 4 million dollars

3. Employment - 18

4. Capacity 20,000 tons/year

5. Year 5 projection

   a) tons/year 100,000
   b) employment 100 - This increase will be due to added lines of more sophisticated products -- such as milling for paint in varsol.

6. Sales at 20,000 tons/year - 3.4 million dollars

PRODUCT

High purity fine size calcium carbonate

USES & USERS

Calcium Carbonate is used as a filler in a wide variety of applications. However, the following are the main categories:

Adhesives -- eg. wall board joint compounds
Paint -- self explanatory
Paper -- as a coating replacing Kaolin Clay
Plastics -- eg. P.V.C. pipe

CANADA

Appendix - Canadian Companies who are potential customers; some are Atlantic like Tibbetts Paints.

U.S.

As there are over 50 potential users in Canada, there are over 500 in the U.S.

The following is a list of some of the "household" names in the U.S:

Adhesives	Paint
Chrysler	Benjamin Moore
Georgia Pacific	CIL
H.B. Fuller	Desoto Inc.
General Sealants	General Paint
National Gypsum	Glidden
National Starch	Industrial Paint
U.S. Gypsum	Koppers
	PPG
	Rust Oleum
	Sherman Williams

TIMING

The ideal situation would be for the foundation of the new production plant to be poured before "freeze-up".

Should that occur then we would expect initial production by June 1988.

MARKET SIZE

1.5 million tons/year

MARKET CLASSIFICATIONS

The aimed for market will be for the higher priced range of applications. Such applications are:

Plastics
Sealants
Paint
Paper

However, the above categories represent some 50% of the total tonnage consumption in North America. The total tonnage represented in the above category is 1.5 million tons per year.

MARKET GROWTH

In accessible areas
Thousands of Tons

	1987	Growth, %	1988	1989	1990	1991
Paint	300	3	309	318	328	339
Paper	400	6	424	449	476	505
Plastics	700	8	756	816	882	952
Sealants and Adhesives	100	5	105	110	116	122
TOTAL	1,500		1,594	1,691	1,802	1,918

PROCESS DEVELOPMENT

The main product requirements are:

a) Fine particle size

b) Whiteness

By Paddle Milling, the fine particle size is achieved. In addition, a marked improvement in whiteness results from

a) ozone production during grinding

b) introduction of a bleaching agent during grinding.

Patent applications are being prepared to cover the above.

The process has been developed by W.J.D. Stone and Magstone Development Inc.

PATENTS

W.J.D. Stone is the inventor of some 100 issued patents. A patent application is being prepared for the process. Although the issue of a Patent can in no way be guaranteed, Stone considers that such an issue is more than likely.

Basis will be:

a) Whitening by ozone creation

b) Whitening by H_2O_2 added during grinding

CAPACITY

20,000 tons per year of end product.

RECOVERY

Virtually 100%

DEPOSIT

An ample supply of raw material is available in Cape Breton.

PRICING

Due to the variety of grades it is difficult to determine a precise average selling price per ton.

However, a product split was made and selling price determined by two routes.

1) Selling prices re Chemical Marketing Report Aug. 8th, 1987 - $230. per ton

Product	US $/ton	Can $/ton	Av.
Slurry Grade		75 US	
2 - 4 Microns (wet)	125 - 139	167 - 185	176
2 - 4 Microns (dry)	123 - 166	133 - 221	187
Ultra Fine (1 micron)	166	221	221
Slurry 70% solids Coated Fine 2 - 3 microns	167	223	223
Ultra Fine Dry	228	304	304

2) Independent Private Report - $ 171. per ton

It could well be argued that a halfway point would be practical, however, a price of $170. per ton has been adopted, knowing this is on the low side.

SALES YEARS 1 - 3

	Year 1	Year 2	Year 3
Tons	5,000	10,000	20,000
Value	$855,000	$1,710,000.	$3,420,000.

QUARRYING

Cape Carbonate will not have any investment in equipment development or operation of the quarry. This will be performed by Mosher Limestone under contract. Mosher has the knowledge, equipment, and access to equipment to quarry amd deliver the quarried product to its agricultural limestone plant.

FINANCIAL COMMENT

Projections have been made on a modest level. This relates both to sales objective and price realized.

However, Year 1 will break even with modest increases in Year 2 and 3.

The important aspect is that the high grade part of the market is expected to be penetrated. This means that:

a) the initial plant will be profitable
b) expansion to 100,000 tons a year will occur.

FEEDSTOCK COSTS

Delivered plant substantially -325 mesh, variable at the following cost:

Tons/Year	5,000	10,000	20,000
$/ton	45.00	42.50	40.00

CAPITAL COSTS

Building - 16,000 sq. ft. @ $50,00 per sq. ft.			$800,000.
Equipment - Process Modules:			
Raw Material Storage Bins	-	$ 20,000.	
Feeder Tanks	-	10,000.	
Pumps	-	50,000.	
Paddle Mills	-	700,000.	
Spray Dryers	-	800,000.	
Holding Tanks	-	20,000.	
Bagging Machines	-	20,000.	
Fuel System	-	50,000.	
		$1,670.000.	
Misc. 20%		334,000.	
Electrical 20%		334,000.	
Mechanical 20%		334,000.	
Plant Commissioning		221,000.	
		$2,893,000.	2,893,000.
			$3,693,000.

COMMISSIONING	4 MONTHS				
Month	1	2	3	4	Total
Ore Tons	200	250	300	400	
	x $45.	x,$45.	x,$45.	x,$45.	
	$,9,000.	$11,250.	$13,500.	$18,000.	$51,750.
Power	1,120.	1,400.	1,680.	2,240.	6,440.
Peroxide	1,000.	1,250.	1,500.	2,000.	5,750.
Grinding Media	4,000.	5,000.	6,000.	8,000.	23,000.
Drying	5,000.	6,250.	7,500.	10,000.	28,750.
Labor	2,400.	3,000.	3,600.	4,800.	13,800.
Foreman	1,200.	1,200.	1,200.	1,200.	4,800.
Management	16,000.	16,000.	16,000.	16,000.	64,000.
Bags and Pallets	1,000.	2,000.	2,500.	3,000.	8,500.
Office Supplies	600.	650.	700.	800.	2,750.
Steno/Bookkeeper	1,200.	1,200.	1,200.	1,200.	4,800.
Quality Control	1,600.	1,600.	1,600.	1,600.	6,400.
	$44,120.	$50,800.	$56,980.	$68,840.	$220,740.

OPERATING COSTS/TON

	Year 1 5,000 tons	Year 2 10,000 tons	Year 3 20,000 tons
Ore/Ton	$45.00	$42.50	$40.00
Power	5.60	5.60	5.60
Peroxide	5.00	5.00	5.00
Grinding Media	20.00	20.00	20.00
Drying	25.00	25.00	25.00
Labor	12.00	12.00	12.00
Foreman	6.00	3.00	1.50
Management	40.00	20.00	10.00
Bags and Pallets	9.00	9.00	9.00
Office Supplies	2.00	1.50	1.00
Steno/Bookkeeper	3.00	1.50	.75
Quality Control	4.00	2.00	1.00
	$176.60	$147.10	$130.85

MARKETING PRE-PRODUCTION

During construction of the plant it is essential to produce sufficient material for customer evaluation and acceptance.

The work falls into two distinct categories.

a) Material:
   Production of material for potential customers
b) Contact:
   Making contact with the potential customers, supplying samples and adjusting such characteristics as grind to meet their requirements.

The initial marketing programme would aim at four major user categories:

Plastics Paper Paint Pharmaceutical

The programme would be handled by Magstone.

Effort would be directed 50% Canada, 50% U.S.A. This ratio would be adjusted according to response.

MARKETING PRE-PRODUCTION COSTS

Material:

2 Technicians $3560 per month for 9 mos	$32,040.	
Lab. rental $1000/month	9,000.	
Lab. supplies $300/month	2,700.	
20 ton ore -¼"	2,000.	
Stenographer/Bookkeeper $500/month	4,500.	
	$50,240.	$50,240.

Marketing:			
	Brochures	5,000.	
	Travel	20,000.	
	Sample shipment etc.	2,000.	
	Tel. etc.	$ 2,000.	
		$29,000.	$29,000.
			$79,240.

OPERATING CAPITAL

$307,000. Although it is obvious that operating capital represents the difference between the total of 4 million dollars and the capital cost, it, nevertheless, is a realistic figure.

This includes Marketing Preproduction in an amount of $80,000.

APPENDIX D

MOSHER LIMESTONE CO. LTD.

MOSHER LIMESTONE

Mosher Limestone Co. Ltd.
Upper Musquodoboit
Nova Scotia, BON 2MO

President: Roy C. Mosher

Mosher Limestone Co. Ltd. has been in the minerals field in Nova Scotia for many years producing sand, gravel, crushed stone, and ground mineral products for a wide variety of uses.

The company operates a number of limestone/dolomite quarries and processing facilities in Nova Scotia. A plant at Middle Musquodoboit producers crushed stone, agricultural limestone, and ground limestone for a variety of purposes. Mosher Limestone additionally custom-grinds other minerals, including barite, for various applications. The company has a very well equipped machine shop at this location and has custom fabricated mills and milling equipment for a variety of clients. A mobile, barite-grinding plant was developed and mounted on two or three flat-bed trailers. One such plant is operating in the Yukon, another in Newfoundland, and a third in Nova Scotia.

The Kellys Cove crushing/screening/grinding plant was constructed in 1986/87. Dolomite from a nearby quarry is crushed, sized and ground for such applications as:

- dusting coal mines (stone dust, 70% minus 150 µm)
- carpet filler (100% minus 50 µm)
- construction aggregate (100% minus 2 mm, 60% minus 150 µm)

The plant at Kellys Cove includes a Raymond Roller Mill that easily grinds to 45 µm.

Mr. Stone of Magstone Development Inc., in discussion with Mr. Mosher of Mosher Limestone, indicated interest in having an adjacent grinding facility to further grind dolomite and/or limestone to 2 µm. This would be

accomplished in the Magstone-developed Paddle mill. In recent discussions, Mr. Mosher expressed continued interest in such a facility. He has, in this regard, held preliminary discussions with Enterprise Cape Breton, a new government group interested in the further development of industry in Cape Breton.